

REMARKS

The Examiner noted text on pages 4, 8, and 9 which need correcting. The changes suggested by the Examiner have all been made.

The claims have been amended to put them into the standard US format. A missing dependency claim number has been added to Claim 8.

Claims 1-2 and 11 were rejected under 35 U.S.C. §102(b) as being anticipated by US Pat. 6,447,453 (Roundhill et al.); US Pat. 6,730,032 (Yamauchi); US Pat. 6,447,450 (Olstad et al.); or US Pat. 6,966,878 (Schoisswohl et al.) Claim 1 describes a method for medical ultrasound imaging, comprising acquiring ultrasound image data representative of three-dimensional volume segments of an image volume in synchronism with cardiac cycles of a subject, each of the volume segments containing image data distributed in three dimensions which is acquired during a cardiac cycle of the subject; acquiring ECG waveforms of the cardiac cycles during which the volume segments are acquired; combining the image data representative of the volume segments to provide image data representative of a three-dimensional ultrasound image of the image volume; and displaying the ECG waveforms in a comparative display in which the uniformity of the waveforms is illustrated. As is conventional in the art, ultrasound data for cardiac imaging is acquired in synchronism with an ECG waveform so that the phases of the heart cycle when the data is acquired is known. This enables data of a common cardiac phase acquired during different heart cycles to be combined in one image, as the heart moves too rapidly to acquire all the information needed for (particularly) a 3D image to be acquired while the heart is beating. The present invention enables the anatomical accuracy of the three dimensional image to be gauged by displaying the ECG waveforms of the acquisition interval in a comparative display so that data acquired for the 3D image during an abnormal heart cycle can be quickly identified by the nonuniformity of the comparative waveforms.

Roundhill et al. are tracing the endocardial border of a 3D ultrasound image and displaying the border tracing as shown for example in Fig. 15a as described in column 13, lines 35-66. Roundhill et al. are using a heart gate triggered from an ECG waveform so that their data is acquired at a known phase of the heart cycle, as is well known. However Roundhill et al. do not show or suggest displaying ECG waveforms in a comparative display in which the uniformity of the waveforms is illustrated. Nor do they use any such comparison of ECG

waveforms to gauge the accuracy of their anatomical display. Accordingly it is respectfully submitted that Roundhill et al. cannot anticipate Claim 1 or its dependent Claims 2-8.

Yamauchi is also acquiring cardiac ultrasound data with an ECG trigger. At column 7, lines 35-39 Yamauchi says he is time-stamping the ultrasound data in synchronism with heart pulsation so that he can interpolate data from different heartbeats but the same phase timing. Yamauchi says nothing about 3D imaging and gives no suggestion of displaying ECG waveforms in a comparative display in which the uniformity of the waveforms is illustrated, as recited in Claim 1. Accordingly it is respectfully submitted that Yamauchi cannot anticipate Claim 1 or its dependent Claims 2-8.

Olstad et al. are recording a sequence of cardiac image frames over different heart cycles, then interpolating them on the basis of phase of acquisition to generate a sequence of synthesized frames. To gauge whether there are any discrepancies in the cardiac cycle that would impair the ability to combine images from different cycles, images acquired at the same phase of the different cycles are compared by image analysis. The comparison employs the familiar block matching correlation using the sum of the square error between each pair of time-aligned images as described at the bottom of column 2. Alternatively, as mentioned at column 8, lines 22-24, a standard deviation may be used. At column 9, lines 56-63 Olstad et al. say that the same techniques can be used for 3D imaging, stressing the importance of ECG-triggered acquisition. Once again there is no suggestion of displaying ECG waveforms in a comparative display in which the uniformity of the waveforms is illustrated, as recited in Claim 1, nor any suggestion of using an ECG waveform comparison to assess the accuracy of a 3D image. Accordingly it is respectfully submitted that Olstad et al. cannot anticipate Claim 1 or its dependent Claims 2-8.

US Pat. 6,966,878 (Schoisswohl et al.) are doing 3D imaging. As described at column 7, lines 12-47, they are acquiring ECG-triggered ultrasound images of a fetal heart, then combining image frames from "a single point in time (relative to the heart cycle)" into a volumetric image. Once again, there is no suggestion of displaying ECG waveforms in a comparative display in which the uniformity of the waveforms is illustrated, as recited in Claim 1, nor any suggestion of using an ECG waveform comparison to assess the accuracy of a 3D image. Accordingly it is respectfully submitted that

Schoisswohl et al. cannot anticipate Claim 1 or its dependent Claims 2-8.

Claim 11 describes a medical diagnostic ultrasound imaging system comprising a transducer comprising an array of transducer elements; a transmitter for transmitting ultrasound energy with said transducer into volume segments of an image volume of interest in a subject as a plurality of transmit beams; a receiver for receiving ultrasound echoes with said transducer from the image volume in response to the ultrasound energy and for generating received signals representative of the received ultrasound echoes; a receive beamformer for processing said received signals to form at least one receive beam for each of the transmit beams and to generate image data representative of the ultrasound echoes in the receive beam; an image memory which stores the image data of a plurality of volume segments; an ECG device coupled to the subject for generating an ECG signal representative of the cardiac cycle during reception of echoes from a volume segment; and a display for displaying an image volume and the ECG signals of the volume segments of the image volume in a comparative display. As previously shown, neither Roundhill et al. nor Yamauchi nor Olstad et al. nor Schoisswohl et al. show or suggest a comparative display of the ECG waveforms of the cardiac cycles from which ultrasound data for a 3D image are acquired. It follows then that none of these patents show or suggest a display for displaying an image volume and the ECG signals of the volume segments of the image volume in a comparative display. Accordingly it is respectfully submitted that none of these four patents can anticipate Claim 11.

Claims 1-2 and 11 were further rejected under 35 U.S.C. §103(a) as being unpatentable over the four patents just described in view of US Pat. 5,813,986 (Ubukata) or further in view of US Pat. 6,730,032 (Yamauchi) or US Pat. 5,551,434 (Iinuma) or US Pat. 6,139,500 (Clark) alone or in view of US Pat. 6,558,325 (Pang et al.) Ubukata mention in the abstract the use of means of identifying automatically a time point of inspection to be of the expansion period (diastole) or the contraction period (systole) of the heart based on a bionomic signal such as an ECG. It is well known that an ECG waveform can be used to identify the diastolic and systolic phases, but this adds nothing to the previous references which illustrate the same thing. Iinuma is another patent where cardiac image

frames are being interpolated and in column 11 Iinuma refers to the display of an ECG waveform in Fig. 12B. Iinuma is not doing 3D imaging and does not relate the ECG to 3D as, for example, Olstad et al. did. Clark is doing 3D cardiac imaging and is using ECG gating. Minor variations in cycle time are overcome by interpolating and resampling the data on a new time scale, then letting scan conversion solve the problem, as described in column 5, lines 35-39 and column 10, lines 25-35. Clark uses no comparative display of ECG waveforms as his interpolation, resampling, and scan conversion processes resolve these problems. Measurements of the cardiac cycle time (columns 8-9) can also be used, but ECG waveform comparison is not suggested. While Clark recognizes the problem solved by the instant invention, he solves it by a different and automated technique. Pang et al. recognize at column 4, lines 5-9 that a sequence of 3D images can be formed from 2D ultrasound image frames acquired at the same phases of the cardiac cycle, which adds nothing to the previously described patents. None of these patents show or suggest displaying ECG waveforms from a volumetric acquisition in a comparative display in which the uniformity of the waveforms is illustrated, or a display for displaying an image volume and the ECG signals of the volume segments of the image volume in a comparative display. Thus it is respectfully submitted that Ubukata, Iinuma, Clark and Pang et al. do not add anything to the four patents initially cited which would render Claims 1-8 and 11 unpatentable.

Claims 3-4 and 12-13 were rejected under 35 U.S.C. §103(a) as being unpatentable over any of the four patents first described above and further in view of US Pat. 6,665,559 (Rowlandson) or US Pat. 3,909,792 (Harris et al.) Rowlandson describes a system which helps interpret an ECG by displaying messages about the probability of cardiovascular risk in concert with ECG waveforms. Besides being helpful in interpreting ECG data, the patent states at the bottom of column 2 that the diagnostic system could also be configured to help interpret other data such as ultrasonic images. There is no suggestion of combining both ECG and ultrasound images in such an interpretive system, and the patent is unrelated to 3D ultrasound imaging. Harris et al. describe an electrocardiographic review system for displaying ECG data for

eight patients. There is no suggestion of displaying comparative ECG data with ultrasound data or with 3D ultrasonic images. Accordingly it is respectfully submitted that Rowlandson and Harris et al. add nothing to the previously described patents that would render Claims 1-8 or 11 unpatentable. Claims 12-13 depend from Claim 11 and it is respectfully submitted that these claims are patentable over this group of references by reason of this dependency.

Claims 5-6, 8, 14, 15 and 17 were rejected under 35 U.S.C. §103(a) as being unpatentable over the patents listed in the preceding paragraph and further in view of US Pat. 6,409,659 (Warner et al.) Warner et al. show comparative ECG data in Fig. 3 which has been acquired by a cardiograph and is colored as a function of amplitude (column 4, lines 15-16) to readily highlight an amplitude shift. However there is no suggestion of showing comparative ECG data for a volumetric ultrasound image, or in showing the comparative ECG data and a volumetric ultrasound image together as recited in Claims 1 and 11. Since Warner et al. cannot be combined with the other citations to render Claims 1 and 11 unpatentable, it follows that their dependent Claims 5-6 and 15 are patentable by their dependency. Furthermore, there is no suggestion of relating the color of different ECG waveforms to the segments of a volumetric image to which they correspond. It is respectfully submitted that Claims 5-6, 8 and 14, 15, 17 are patentable for this further reason.

Claims 7 and 16 were rejected under 35 U.S.C. §103(a) as being unpatentable over the patents cited against Claim 1 and discussed above, in view of US Pat. 3,951,135 (Goldberg et al.) Goldberg et al. show in Fig. 5 a conventional ECG strip-chart recording but with the ECG waveforms displayed in a compressed manner. There is no suggestion of displaying in a comparative manner the ECG waveforms used for volumetric ultrasound acquisition, nor of displaying both a volumetric ultrasound image and the comparative ECG waveforms together. This it is respectfully submitted that Goldberg et al. adds nothing to the patents cited against Claim 1 that would render Claims 1 or 11 or their dependent Claims 7 and 16 unpatentable. Furthermore, the strip-chart recorder does not trace the ECG waveforms in an overlapping manner. It is

respectfully submitted that Claims 7 and 16 are patentable for this further reason.

Claims 9-10 were rejected under 35 U.S.C. §103(a) as being unpatentable over the patents applied to Claim 1 above and further in view of Clark. Claim 9 describes a method for medical ultrasound imaging, comprising acquiring ultrasound image data representative of three-dimensional volume segments of an image volume in synchronism with cardiac cycles of a subject, each of the volume segments containing image data distributed in three dimensions which is acquired during a cardiac cycle of the subject; acquiring ECG waveforms of the cardiac cycles during which the volume segments are acquired; comparing the ECG waveforms; reacquiring the ultrasound image data of a volume segment having an ECG waveform which is dissimilar from the ECG waveforms of other volume segments; combining the image data representative of the volume segments to provide image data representative of a three-dimensional ultrasound image of the image volume; and displaying a three-dimensional ultrasound image of the image volume. By comparing the ECG waveforms of the cardiac cycles during which volume segments are acquired the data from a dissimilar ECG waveform can be reacquired for the formation of a precise volumetric image. Clark employs a measurement of the cardiac cycle time and if a severe cardiac cycle aberration is detected the data can be reacquired. The comparison of ECG waveforms, rather than just looking at the duration of the cardiac cycle time, can reveal problems that would escape the Clark approach. For example, if one cardiac cycle was of the same duration as the others but had a distinctly different ratio of time spent in systole to diastole as compared to the others, the ECG waveform comparison of Claim 9 would pick up this discrepancy, whereas a time duration comparison as Clark advocates will not. For these reasons it is respectfully submitted that Claim 9 is patentable over Clark in combination with the other citations.

Claim 10 describes a method for medical ultrasound imaging, comprising acquiring ultrasound image data representative of three-dimensional volume segments of an image volume in synchronism with cardiac cycles of a subject, each of the volume segments containing image data distributed in three dimensions which is acquired during a cardiac cycle

of the subject; acquiring ECG waveforms of the cardiac cycles during which the volume segments are acquired; combining the image data representative of the volume segments to provide image data representative of a three-dimensional ultrasound image of the image volume; comparing the ECG waveforms; replacing the ultrasound image data of a volume segment having an ECG waveform which is dissimilar from the ECG waveforms of other volume segments; and displaying a three-dimensional ultrasound image of the image volume. Claim 10 describes the step of comparing ECG waveforms from volumetric acquisition which, as just explained, is missing from Clark. In addition Claim 10 recites replacing the ultrasound data of a volume segment having a dissimilar ECG waveform. Clark appears unable to do this, as an entire volume is rendered together (step 632); there is no mention of replacing the data of just a segment of a volume. Accordingly it is respectfully requested that Claim 10 is patentable over the cited patents for this further reason.

The Jackson and Pini patents cited but not applied have been reviewed and are not believed to affect the patentability of the claims discussed above.

In view of the foregoing amendments and remarks it is respectfully submitted that the defects in the specification and claims have been resolved, that Claims 1-2 and 11 are not anticipated by Roundhill et al., Yamauchi, Olstad et al. or Schoisswohl et al., and that Claims 1-17 are patentable over the combination of Roundhill et al., Yamauchi, Olstad et al. or Schoisswohl et al., Ubukata, Iinuma, Clark, Rowlandson, Harris et al., and Warner et al. Accordingly it is respectfully requested that the rejection of Claims 1-2 and 11 under 35 U.S.C. §102(b) and of Claims 1-17 under 35 U.S.C. §103(a) be withdrawn.

In light of the foregoing amendment and remarks, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,

DOUGLAS A. DEMERS

By: W Brinton Yorks, Jr.
W. Brinton Yorks, Jr.
Reg. No. 28,923

Philips Electronics
22100 Bothell Everett Highway
P.O. Box 3003
Bothell, WA 98041-3003
(425) 487-7152
March 27, 2006